GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Date: 12/22/69

Project Title: Radiation Effects on Textile Waste Solutions

Project No.: B-374

Project Director: Dr. G. G. Eichholz

Sponsor: NSF Institutional Grant GU-3309

Effective ..... December 16, 1969 .... Estimated to run until: ... June 30, 1971* ....

Type Agreement: NSF Grant - Controller's Account No. B-2815 Amount: $ 3,960.00 ....

Reports: Progress Report - due by December 1, 1970 - on use of NSF funds for period ending June 30, 1970.

Contact Person: Dr. Vernon Crawford
Vice President for Academic Affairs

*Note: Project will terminate: 1) When budget balance is less than $50.00
2) No charges made during any three month period
3) Completion of work
4) June 30, 1971

Whichever occurs first.

Assigned to ... Nuclear & Biological Sciences ...... Division

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RA-62(12-66)

GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT TERMINATION

Date 2/18/71

PROJECT TITLE: Radiation Effects on Textile Waste Solutions

PROJECT NO: B-374

PROJECT DIRECTOR: Dr. G. G. Eichholz

SPONSOR: NSF Institutional Grant

TERMINATION EFFECTIVE: 2/18/71

CHARGES SHOULD CLEAR ACCOUNTING BY: All charges cleared. Overrun XXXXXXXX to be transferred to Division account.

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RADIATION EFFECTS ON TEXTILE WASTE SOLUTIONS

Final Report on Project B-374

under NSF Institutional Grant GU-3309

Prepared by

G. G. Eichholz and T. F. Craft

School of Nuclear Engineering
and
Nuclear & Biological Sciences Division
Engineering Experiment Station
Georgia Institute of Technology

December 1, 1970

Introduction

Dyes are an important constituent of the liquid wastes produced by the textile industry. Many dyes are resistant to biological oxidation and pass relatively unchanged through conventional waste treatment plants. The resulting effluent may have a bright color or may be the dirty grey characteristic of mixtures of dyes. Such effluents are unaesthetic and may be toxic to stream biota.

Non-conventional treatment processes that have been tried or suggested include adsorption by activated carbon, exposure to ultraviolet or gamma radiation, and chemical oxidation. All of these methods of treatment improve the quality of water, but none can be considered technically and economically satisfactory.

Experience in other areas suggested that a synergistic mechanism involving simultaneous irradiation and oxydation might be more effective than either process alone. To check this assumption, some experiments combining gamma irradiation and a chemical oxidant have been carried out in our laboratory. The project was initiated March 15, 1970 with the primary purpose of exploring the feasibility of this process and performing some preliminary tests on representative dyes. Suitable dyes were selected on the advice of Dr. R. K. Flege, School of Textile Engineering, who has long been concerned with the characteristics of effluents from textile mills.

Experimental Procedure

The experimental procedure consisted of adding sodium hypochlorite solution to a portion of dye solution. This was quickly mixed and lowered into the 12,000 curie cesium-137 gamma irradiator in an exposure position where the dose was about one megarad per hour. After remaining in the radiation field for the chosen length of time, the solution was promptly transferred to the cuvette of a spectrophotometer and the transmittance was measured. Subsequent transmittance measurements were made at short intervals. For comparison, other portions of the dye solution were treated individually with sodium hypochlorite or subjected to irradiation only.

The observed values of transmittance were plotted as a function of time, with zero being the moment at which the sample entered the high radiation field. Some time is required to add the oxidant, mix, and lower the sample into the source, but this amounted only to about 15 seconds. Almost one minute was required to remove the sample, transfer it to the spectrophotometer and obtain a reading; initial readings for irradiated samples are therefore shown at the length of irradiation plus one minute. Zero time transmittance was measured prior to any treatment. Figures 1-3 are representative of the results obtained.

"Violet BN" is a commercial dye that consists of a mixture of anthraquinone compounds. The exact structures of this material have not been published, but the two major compounds present are reported to contain one or two amine nitrogens or an amine nitrogen plus a hydroxyl group. The results of several experiments on this material are summarized in figure 1. The stock solution at a concentration of 0.025 g/ℓ had a transmittance at 461 mμ of 21.5%. Exposure of this solution to 167 kilorads of gamma radiation had only a very slight effect, raising the transmittance by only 0.6%, and this value remained constant. Another portion of stock solution was treated with sodium hypochlorite solution equivalent to 100 mg/ℓ of chlorine. The transmittance of this mixture increased steadily during the hour following mixing.

Much more pronounced effects resulted from the combination of treatments. It was found that for a dose of 166 kilorads, solutions containing either 100 or 200 ppm chlorine gave the same results; an initial increase to 33.7% followed by a further increase on standing during the remainder of the hour.

modification of the dye molecules, or to delayed chlorine attack. These effects will require further study to elucidate the mechanisms involved more fully, particularly as a function of temperature, oxygen content, and concentration. It is significant that most of the decoloration effects occur close to the beginning of the irradiation--chlorination, and are limited probably mainly by the diffusion control of potential scavengers. From the economic point of view, of course, the lowest effective dose is the most desirable.

To explore the effect of the combined treatment on the biological degradability of the dyes or the irradiation products, extensive COD determinations were performed. Initial results seemed to indicate significant changes in COD for the combined treatment, but these were not confirmed by later, more carefully controlled tests. In general, it was observed that considerably higher radiation doses seemed to be required to obtain significant changes in COD than were needed to obtain the degree of decoloration exhibited in Figures 1-3.

Conclusions

The test work, though admittedly of a preliminary nature only, has shown that considerable acceleration and effectiveness may be obtained in the treatment of certain dye wastes, used in the textile industry, by the simultaneous application of gamma radiation and chlorination. Considerably more work is required to establish optimum conditions for a given dye mixture and to determine biological degradability, and even potential toxicities. Similarly, economic feasibility and practical plant design have to await the completion of further test work.

The work described in this report has been sufficiently encouraging to prompt the award by the Federal Water Quality Agency of a research grant to explore the potential of this method more fully. Future work will form part of that project (B-391).

The work has also benefited some students in the School of Nuclear Engineering in the form of a special research project (NE 732) and experience in research participation.

Identification of some of the irradiation products may be the subject of an M.S. thesis in textiles during the next few months.

Additionally, some work has been started to test possible radiation effects on the photosensitive effluents from explosives plants that may be amenable to treatment by this process. This subject may become the topic of a separate research project.

Project Personnel

Dr. G. G. Eichholz, Professor of Nuclear Engineering

Dr. T. F. Craft, Research Chemist, Engineering Experiment Station

Ronald L. Swanson (graduate student, N.E.)

Harry Taylor (graduate student, N.E.)

Martin Lopez, Jr. (work-study (EE) student)

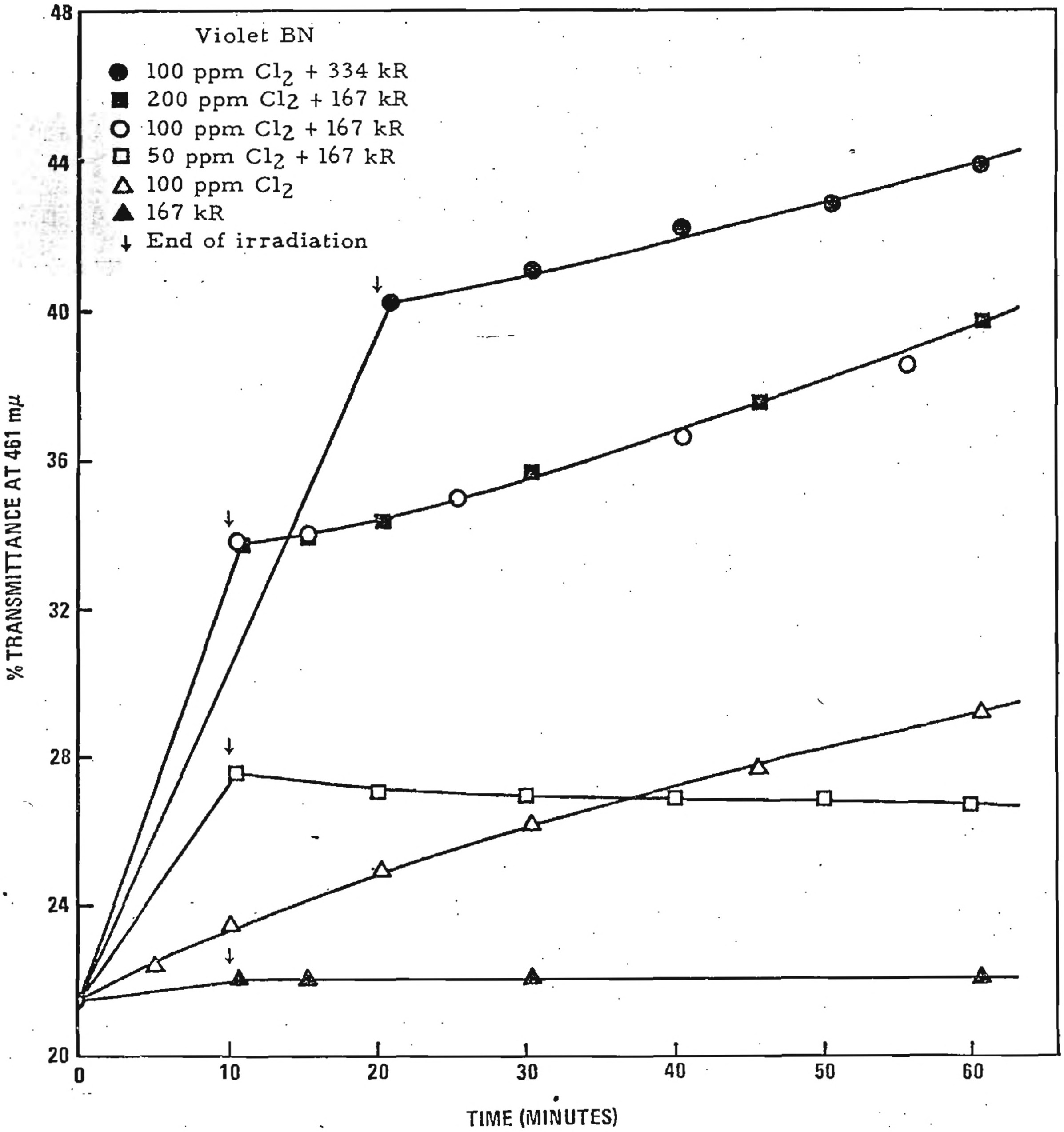

Fig. 1 Transmittance changes for Violet BN

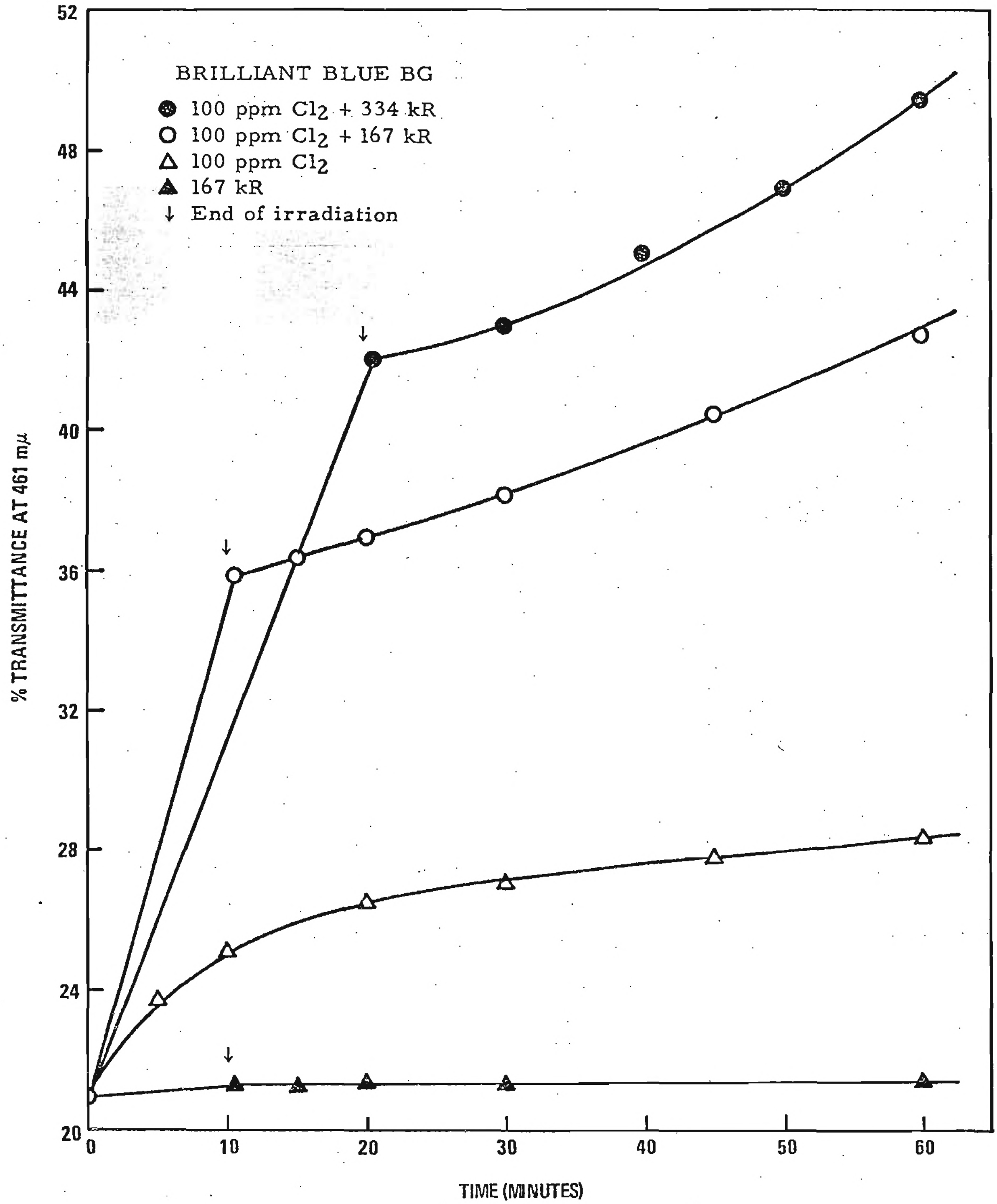

Fig. 2 Transmittance changes for Brilliant Blue BG

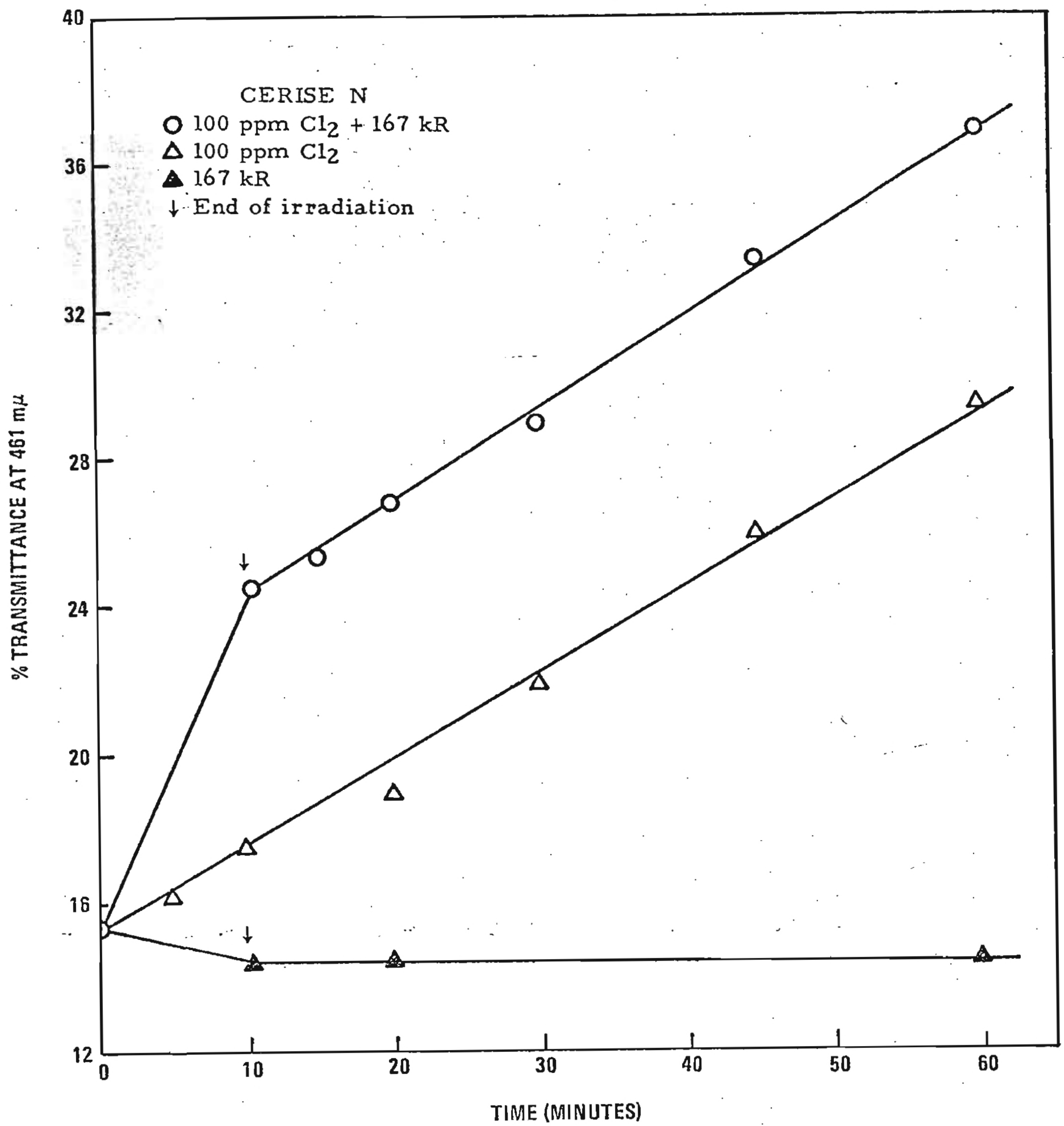

Fig. 3 Transmittance changes for Cerise N